Estuarine, Coastal and Shelf Science

A method to quantify water quality change in data-limited estuaries

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Abstract

Situated at the land-sea interface, estuaries are susceptible to land- and sea-based sources of pollution. Despite growing scientific evidence of deterioration in water quality, quantitative methods to translate such information in support of effective environmental management and planning practice is lacking, particularly in data-limited environments such as South Africa. Here we expand and improve on existing box model-type methods suitable for data-limiting environments, by providing greater spatial (zoning) and temporal (seasonal and exceedance patterns) resolution. In doing so, usefulness and repeatability for valuation of ecological or socio-economic responses are enhanced. Framed by three key design principles, the method comprises six main steps. First, hydrological simulations representative of long-term freshwater inflow patterns is generated, for example for natural, present, or potential future development or climate change scenarios. Then the estuary is divided into representative homogenous zones, to reduced spatial complexities while still allowing for some longitudinal resolution. Step three involves the identification of characteristic physical states linked to typical freshwater inflow patterns, followed by the development of water quality matrices depicting zonal distribution of biogeochemical properties representative of each physical state. Using the simulated monthly hydrological time series as input, the water quality matrices are then extrapolated over the longer period to derive seasonal- and exceedance distribution patterns for selected scenarios. A similarity index is applied to demonstrate how outputs could be aggregated into an overall water quality condition. Based on a real-world application, the method is considered useful as a systematic and transparent process to capture change in water quality in a digestible, quantitative manner in support of effective evidence-based management interventions. The method can be applied at any data resolution, but the confidence of outputs will depend on the amount and accuracy of available data to define hydrological simulations and to construct the water quality matrices. The method aligns well with existing methods applied in estuarine management in South Africa, and we pose this as a useful approach for application in estuaries with similar linear-like, shallow characteristics

for example, along the North and South American temperate coasts, the Mediterranean and the Australian south-west and south-eastern coasts.